Enantioselective Synthesis of 10-*epi*-Anamarine via an Iterative Dihydroxylation Sequence

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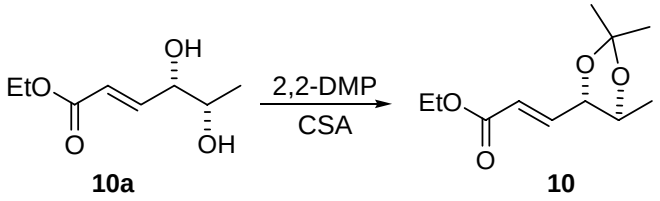
Supporting Information:

General Methods and Materials. ^{1}H and ^{13}C NMR spectra were recorded on Jeol (270 MHz) and Varian VXR-600 (600 MHz) spectrometers. Chemical shifts are reported relative to internal tetramethylsilane (δ 0.00 ppm) or $CDCl_3$ (δ 7.26 ppm) for ^{1}H NMR and $CDCl_3$ (δ 77.0 ppm) for ^{13}C NMR. Infrared (IR) spectra were obtained on a Prospect MIDAC FT-IR spectrometer. Optical rotations were measured with a Jasco DIP-370 digital polarimeter in the solvent specified. Melting points were determined with Electrothermal Mel-Temp apparatus and are uncorrected. Flash column chromatography was performed on ICN reagent 60 (60-200 mesh) silica gel. Analytical thin-layer chromatography was performed with precoated glass-backed plates (Whatman K6F 60Å, F_{254}) and visualized by quenching of fluorescence and by charring after treatment with *p*-anisaldehyde or phosphomolybdic acid or potassium permanganate stain. R_f values are obtained by elution in the stated solvent ratios (v/v). Ether, THF, methylene chloride and triethylamine were dried by passing through activated alumina (8 x 14 mesh) column with argon gas pressure. Commercial reagents were used without purification unless otherwise noted. Melting points are uncorrected. Air and/or moisture-sensitive reactions were carried out under an atmosphere of argon/nitrogen using oven/flamed-dried glassware and standard syringe/septa techniques.

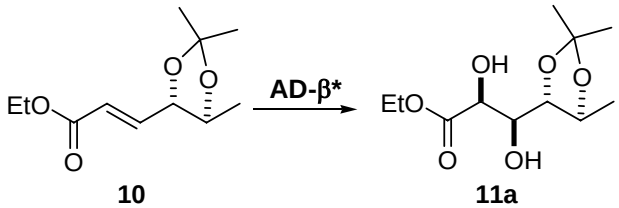
(*E*,4'*S*,5'*S*)-ethyl 3-(2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)acrylate (10).



10a **10**

To a stirred solution of (*E*,4*S*,5*S*)-ethyl 4,5-dihydroxyhex-2-enoate **10a** (300 mg, 1.72 mmol) in 2 mL of CH_2Cl_2 at room temperature was added 2,2-DMP (0.42 ml, 3.44 mmol) and CSA (8 mg, 2 mol%). The reaction was stirred for 3 h and quenched with saturated aqueous sodium bicarbonate (10 mL) and the aqueous layer was extracted with ether (3 x 15 mL). The combined organic layers were washed with brine (25 mL), and dried over anhydrous sodium sulfate. After removal of the solvents *in vacuo*, flash chromatography on silica gel (9:1 (v/v) hexanes/EtOAc) afforded (*E*)-ethyl 3-((4*S*,5*S*)-2,2,5-trimethyl-1,3-dioxolan-4-yl)acrylate **10** as a viscous oil (310 mg, 83%): R_f = 0.56 (7:3 (v/v) hexane/EtOAc); $[\alpha]^{25}_D$ +6.5° (*c* 2.2, CH_2Cl_2); IR (thin film, cm^{-1}) 2985, 2936, 2876, 1723, 1663, 1454, 1373, 1302, 1249, 1175, 1107, 1036, 980; ^{1}H NMR ($CDCl_3$, 600 MHz) δ 6.85 (dd, *J* = 15.6, 6 Hz, 1H), 6.11 (dd, *J* = 15.6, 1.2 Hz, 1H), 4.22 (q, *J* = 7.2 Hz, 1H), 4.19 (q, *J* = 7.2 Hz, 1H), 4.07 (qd, *J* = 6, 2.4 Hz, 1H), 3.83 (ddd, *J* = 8.4, 6, 2.4 Hz, 1H), 1.31(d, *J* = 6 Hz, 3H), 1.44 (s, 3H), 1.41 (s, 3H), 1.29 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ 165.9, 143.4, 122.8, 119.2, 81.6, 76.4, 60.6, 27.2, 26.6, 16.6, 14.2; HRMS (CI) calcd for $[C_{11}H_{18}O_4 + Na]^+$: 237.1097, Found: 237.0995.

(2*S*,3*S*)-ethyl 2,3-dihydroxy-3-((4'*S*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)propanoate (11a):

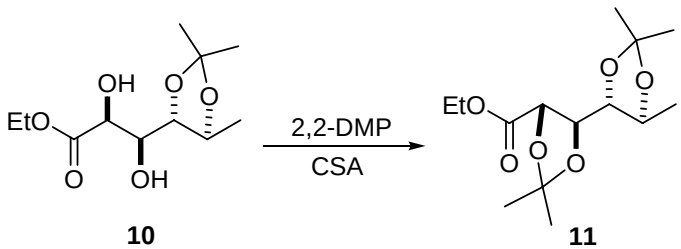


10 **11a**

Into a 50 mL round bottom flask was added 2 mL of *t*-BuOH, 2 mL of water, $K_3Fe(CN)_6$ (461 mg, 1.4 mmol), K_2CO_3 (193 mg, 1.4 mmol), $NaHCO_3$ (117 mg, 1.4 mmol), $MeSO_2NH_2$ (45 mg, 0.47 mmol), $(DHQD)_2PHAL$ (15 mg, 0.02 mmol, 4 mol%), and

OsO_4 (3 mg, 0.01 mmol, 2 mol%). The mixture was stirred at room temperature for about 15 minutes and then cooled to 0 °C. To this solution was added a solution (*E*)-ethyl 3-((4*S*,5*S*)-2,2,5-trimethyl-1,3-dioxolan-4-yl)acrylate **10** (100 mg, 0.47 mmol) in 1 mL of CH_2Cl_2 and the reaction was stirred vigorously at 0 °C for 12h. The reaction was quenched with solid sodium sulfite (100 mg) at room temperature. Then the mixture was filtered through a pad of celite/florisil and eluted with (2 x 20 mL) ethyl acetate. The combined organic layers were dried over anhydrous sodium sulfate and the solvent was removed *in vacuo*. The crude product was purified by flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) to yield (2*S*,3*S*)-ethyl 2,3-dihydroxy-3-((4*S*,5*S*)-2,2,5-trimethyl-1,3-dioxolan-4-yl)propanoate **11a** (110 mg, 10:1 dr, 95% yield) as a viscous oil. The major isomer was separated by column chromatography. Major isomer: white crystalline solid; mp 86-87 °C; R_f = 0.42 (6:4 (v/v) hexane/EtOAc); $[\alpha]^{25}_D$ +11.4° (*c* 2, CH_2Cl_2); IR (thin film, cm^{-1}) 3334, 2987, 2937, 1735, 1662, 1578, 1416, 1331, 1298, 1140, 988, 884; ^1H NMR ($CDCl_3$, 600 MHz) δ 4.44 (dd, *J* = 4.2, 1.8 Hz, 1H), 4.30 (q, *J* = 7.2 Hz, 2H), 4.13 (dq, *J* = 7.8, 6 Hz, 1H), 3.90 (ddd, *J* = 10.2, 9, 1.8 Hz, 1H), 3.61 (ddd, *J* = 9, 7.8, 1.2 Hz, 1H), 3.14 (d, *J* = 4.2 Hz, 1H), 2.20 (d, *J* = 10.2 Hz, 1H), 1.42 (s, 3H), 1.39 (s, 3H), 1.38 (d, *J* = 6 Hz, 3H), 1.33 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 173.3, 108.6, 80.9, 76.5, 73.7, 70.7, 62.3, 27.4, 26.9, 19.4, 14.1; HRMS (CI) calcd for $[C_{11}H_{20}O_6 + Na]^+$: 271.1152, Found: 271.1163.

(2*S*,3*R*)-ethyl 2,2-dimethyl-5-((4*R*,5*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)-1,3-dioxolane-4-carboxylate (11).

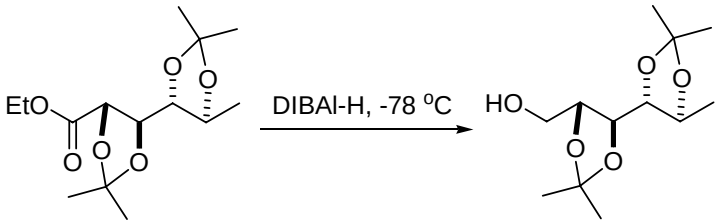


10 **11**

To a solution of diol **10** (543 mg, 2.19 mmol) in 5 mL of CH_2Cl_2 was added 2,2-dimethoxypropane (1.3 mL, 3.45 mmol) and CSA (20 mg, 4 mol%) at room temperature. The reaction was stirred for 24 h and quenched with sat'd aqueous $NaHCO_3$. The

aqueous layer was extracted with Et_2O. The combined organic layers were wished with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **11** (504 mg, 80% yield) as a colorless oil. R_f = 0.61 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1752; $[\alpha]^{25}_D$ +19.8^o (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz): δ 4.49 (d, *J* = 5.2, 1H), 4.27 (dd, *J* = 6.0, 6.0 Hz, 1H), 4.23 (q, *J* = 7.2 Hz, 1H), 4.22 (q, *J* = 7.2 Hz, 1H), 4.04 (dq, *J* = 7.8, 6.0 Hz, 1H), 3.63 (dd, *J* = 7.2, 7.2 Hz, 1H), 1.44 (s, 3H), 1.40 (s, 3H), 1.39 (s, 3H), 1.34 (s, 3H), 1.33 (d, *J* = 6.0 Hz, 3H), 1.28 (dd, *J* = 7.2, 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 171.0, 111.9, 108.9, 82.2, 79.7, 77.0, 75.3, 61.4, 27.4, 27.1, 26.7, 25.9, 18.4, 14.0; HRMS (CI) calcd for $[C_{14}H_{24}O_6 + Na]^+$: 311.1465, Found: 311.1460.

((2*S*,3*R*)-2,2-dimethyl-5-((4'*R*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)-1,3-dioxolane-4-yl)methanol (11a).

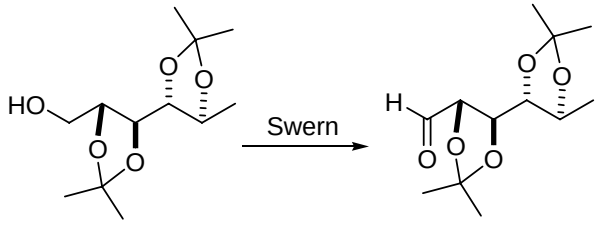


11 **12a**

To a solution of ester **11** (520 mg, 0.52 mmol) in 8 mL of THF was added DIBAL-H (4.5 ml, 20% wt in toluene, 5.4 mmol) dropwise at –78 ^{o}C. In 30 min, the reaction was quenched by adding 1 mL of acetone and 5 mL of 10% NaOH solution. The mixture was filtered through a pad of celite. The aqueous layer was extracted with Et_2O, the combined organic layers were wished with brine, dried over anhydrous Na_2SO_4 and concentrated to afford the crude product. Flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided compound **12a** (411mg, 93% yield) as a colorless oil. R_f = 0.20 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3369, 2989, 1456; $[\alpha]^{25}_D$ –13.8 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 4.09-4.03 (m, 1H), 3.80 (ddd, *J* = 11.4, 4.8, 4.2 Hz, 1H), 3.76 (dd, *J* = 8.4, 7.8 Hz, 1H), 3.72 (dd, *J* = 8.4, 7.8 Hz, 1H), 3.50 (dd, *J* = 8.4, 7.8 Hz, 1H), 2.40 (dq, *J* = 4.8, 4.2 Hz, 1H), 1.41 (s, 3H), 1.40 (s, 3H), 1.38 (s, 3H), 1.37 (d, *J* =

6.0 Hz, 3H), 1.36 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 109.6, 109.1, 82.7, 81.0, 79.4, 77.1, 62.7, 27.3, 26.9, 26.8, 26.7, 18.3; HRMS (CI) calcd for $[C_{12}H_{22}O_5 + Na]^+$: 269.1359, Found: 269.1352.

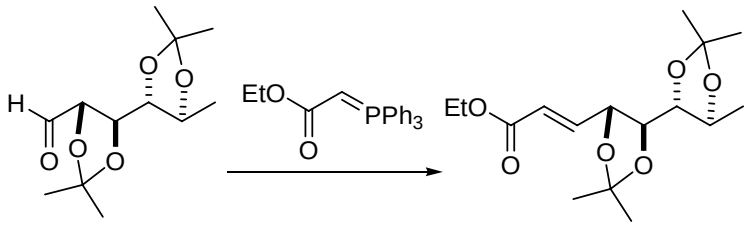
(2*S*,3*R*)-2,2-dimethyl-5-((4'*R*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)-1,3-dioxolane-4-carbaldehyde (12).



12a **12**

To a solution of oxalylchloride (174 mg, 1.37 mmol) in 3 mL of CH_2Cl_2 was added DMSO (134 mg, 1.71 mmol) at –78 °C. After stirring for 10 min, alcohol **12a** (280 mg, 1.14 mmol) in l mL of CH_2Cl_2 was added dropwise. The mixture was stirred for another 10 min, and then Et_3N (375 mg, 3.3 mmol) was added. In 20 min, the dry ice was removed and the solution was stirred for 30 min and quenched with sat'd aqueous $NaHCO_3$. The aqueous layer was extracted with EtOAc. The combined organic layers were wished with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided compound **12** (239 mg, 86% yield) as a colorless oil. R_f = 0.23 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2986, 1741; $[\alpha]^{25}_D$ = –16.3° (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 600 MHz) δ 9.76 (d, *J* = 0.6, 1H), 4.48 (dd, *J* = 6.0, 1.2 Hz, 1H), 4.10 (dd, *J* = 7.2, 6.0 Hz, 1H), 4.04 (ddd, *J* = 10.2, 7.2, 6.0 Hz, 1H), 3.64 (dd, *J* = 7.8, 7.2 Hz, 1H), 1.48 (s, 3H), 1.42 (s, 3H), 1.39 (s, 3H), 1.37 (d, *J* = 6.0 Hz, 3H), 1.36 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 199.9, 111.9, 109.1, 83.3, 82.3, 77.8, 75.9, 27.4, 27.0, 26.8, 26.3, 18.3; HRMS (CI) calcd for $[C_{12}H_{20}O_5 + Na]^+$: 267.1203, Found: 267.1197.

(*E*)-ethyl 3-((2'*R*,3'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1,3-dioxolane-4'-yl)acrylate (13).



12 **13**

To a solution of aldehyde **12** (161 mg, 0.66 mmol) in 4 mL of CH_2Cl_2 was added yield (460 mg, 1.32 mmol) at rt. In 2 h, the solvent was removed *in vacuo*. The crude product was purified by flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided acetonide **13** (168 mg, 81% yield) as a colorless oil. R_f = 0.57 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1714; $[\alpha]^{25}_D$ +14.0 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 6.99 (dd, *J* = 15.6, 4.3 Hz, 1H), 6.14 (dd, *J* = 15.8, 1.8 Hz, 1H), 4.56 (ddd, *J* = 7.5, 4.3, 1.8 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 4.01 (dd, *J* = 7.5, 6.2 Hz, 1H), 3.68 (dd, *J* = 7.9, 7.5 Hz, 1H), 3.54 (dd, *J* = 7.7, 7.7 Hz, 1H), 1.40 (s, 3H), 1.39 (s, 6H), 1.34 (d, *J* = 5.9 Hz, 3H), 1.33 (s, 3H), 1.27 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.3, 145.0, 121.4, 110.4, 109.1, 83.1, 81.5, 79.3, 76.6, 60.5, 27.4, 27.0, 26.9, 26.8, 18.5, 14.3; HRMS (CI) calcd for $[C_{16}H_{26}O_4 + Na]^+$: 337.1622, Found: 337.1618.

Ethyl (6*S*,7*S*)-4,5-dihydroxy-2,4-octdienoate (14a).

5b **14a**

To a 500 mL round bottom flask was added 1:1 *t*-butyl alcohol (160 mL)/water (160 mL), $K_3Fe(CN)_6$ (45.0 g, 136.8 mmol), K_2CO_3 (18.9 g, 136.8 mmol), $CH_3SO_2NH_2$ (4.33 mg, 45.6 mmol), $(DHQ)_2$-PHAL (702 mg, 2 mol%), OsO_4 (116 mg, 1 mol%). The mixture was stirred at room temperature for 15 min and then cooled to 0 ^oC. To this solution was added trienoate **5b** (7.57 g, 45.6 mmol) in 10 mL of *t*-butyl alcohol/water: 1/1 and the reaction was stirred vigorously at 0 ^oC overnight. Sat. aqueous sodium sulfite (70 mL) was added to quench the reaction while stirring vigorously. Ethyl acetate (80 mL) was added to the reaction mixture, and after separation of the layers, the aqueous layer was further extracted with ethyl acetate (3 x 25 mL). The combined organic layers were

washed with 2N KOH (60 mL) and brine to remove the methanesulfonamide, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (1:1 (v/v) hexane/EtOAc) provided compound **14a** (7.57 g, 83% yield) as a colorless oil. R_f = 0.16 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3414, 2982, 1702; $[\alpha]^{25}_D = -48^o$ (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 7.23 (dd, *J* = 15.4, 10.5 Hz, 1H), 6.42 (dd, *J* = 15.2, 11.1 Hz, 1H), 6.05 (dd, *J* = 15.2, 6.2 Hz, 1H), 5.87 (d, *J* = 15.4 Hz, 1H), 4.17 (q, *J* = 7.1 Hz, 2H), 3.94 (dd, *J* = 10.5, 6.3 Hz, 1H), 3.64 (dq, *J* = 10.2, 6.3 Hz, 1H), 3.00 (bs, 1H), 2.76 (bs, 1H), 1.26 (t, *J* = 7.1 Hz, 3H), 1.16 (d, *J* = 6.3 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 167.0, 143.6, 140.7, 129.6, 122.2, 70.6, 60.5, 18.9, 14.3, 14.0; HRMS (CI) calcd for $[C_{10}H_{16}O_4 + Na]^+$: 223.0941, Found: 223.0937.

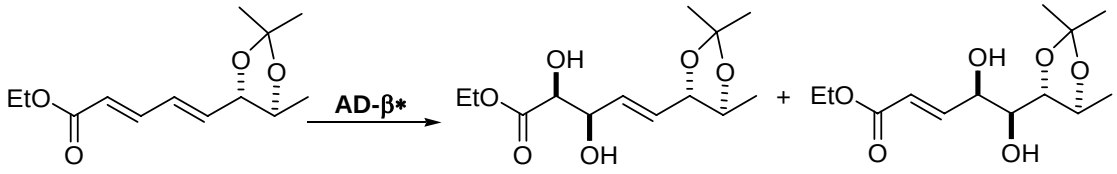
(2*E*,4*E*)-ethyl 5-((4'*S*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)penta-2,4-dienoate (14).

14a **14**

To a solution of diol **14a** (3.0 g, 15.0 mmol) in 150 mL acetone was added 2,2-dimethoxypropane (18.5 mL, 150 mmol) and *p*-toluenesulfonic acid monohydrate (0.29 g, 1.5 mmol) at 0 ^oC. In an hour, the reaction was quenched by adding sat'd $NaHCO_3$ and the mixture was filtered through a pad of celite. The aqueous layer was separated extracted with Et_2O, the combined organic layers were wished with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **14** (3.12 g, 87% yield) as a colorless oil. R_f = 0.63 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2984, 1716; $[\alpha]^{25}_D = -2.1^o$ (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 7.22 (dd, *J* = 15.6, 10.9 Hz, 1H), 6.40 (dd, *J* = 15.1, 10.9 Hz, 1H), 5.98 (dd, *J* = 15.1, 6.8 Hz, 1H), 5.87 (d, *J* = 15.6 Hz, 1H), 4.17 (q, *J* = 7.2 Hz, 2H), 3.97 (dd, *J* = 7.9, 7.4 Hz, 1H), 3.78 (dq, *J* = 8.4, 5.9 Hz, 1H), 1.40 (s, 3H), 1.39 (s, 3H), 1.26 (t, *J* = 7.2 Hz, 3H), 1.23 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.5, 142.9, 137.6, 130.4, 122.4, 108.7, 82.6, 76.5, 60.2, 27.1,

26.6, 16.4, 14.1; HRMS (CI) calcd for $[C_{13}H_{20}O_4 + Na]^+$: 263.1254, Found: 263.1241.

(*E*,2*S*,3*R*)-ethyl 2,3-dihydroxy-5-((4'*S*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)pent-4-enoate (15a) and **(*E*,2*R*,3*S*)-ethyl 4,5-dihydroxy-5-((4'*S*,5'*S*)-2',2',5'-trimethyl-1',3'-dioxolan-4'-yl)pent-2-enoate (15b).**



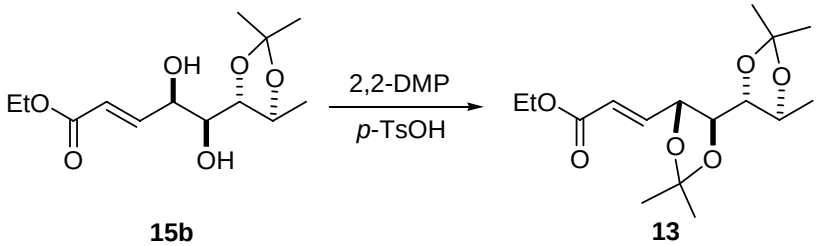
14 **15a** **15b**

To a 250 mL round bottom flask was added 1:1 *t*-butyl alcohol (50 mL)/H_2O (50 mL), $K_3Fe(CN)_6$ (7.9 g, 24.2 mmol), K_2CO_3 (3.34 mg, 24.2 mmol), $CH_3SO_2NH_2$ (765 mg, 8.05 mmol), $(DHQD)_2$-PHAL (260 mg, 0.32 mmol, 4 mol%) and OsO_4 (41 mg, 0.16mmol, 2 mol%). The mixture was stirred at room temperature for 15 min and then cooled to 0 ^oC. To this solution was added acetonide **14** (1.93 g, 8.05 mmol) dropwise and the reaction was stirred vigorously at 0 ^oC overnight. Sat. aqueous sodium sulfite (50 mL) was added to quench the reaction while stirring vigorously. Ethyl acetate (20 mL) was added to the reaction mixture, and after separation of the layers, the aqueous layer was further extracted with ethyl acetate (3 x 25 mL). The combined organic layers were washed with 2N KOH (40 mL) and brine (20 mL) to remove the methanesulfonamide, dried over anhydrous Na_2SO_4, and concentrated to afford the crude mixture of regioisomers (**15a/15b** = 1/1 determined by ^1H NMR). Flash chromatography on silica gel (1:1 (v/v) hexane/EtOAc) provided the two pure regioisomers 1.86 g, 85% combined yield. **15a** (929 mg, 42.5% yield), a colorless oil. **15b** (929 mg, 42.5%) a white solid.

15a: R_f = 0.10 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3446, 2983, 1762; $[\alpha]^{25}_D$ +27.9 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 5.88 (dd, *J* = 15.4, 5.7 Hz, 1H), 5.70 (ddd, *J* = 15.6, 7.1, 1.2 Hz, 1H), 4.38 (bs, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 4.08 (dd, *J* = 6.1, 3.0 Hz, 1H), 3.88 (dd, *J* = 7.9, 7.5 Hz, 1H), 3.70 (dd, *J* = 8.5, 5.9 Hz, 1H), 3.62 (d, *J* = 6.3 Hz, 1H), 3.23 (dd, *J* = 4.9, 4.0 Hz, 1H), 2.71 (dd, *J* = 8.1, 7.9 Hz, 1H), 1.34 (s, 3H), 1.32 (s, 3H), 1.23 (t, *J* = 7.1 Hz, 3H), 1.18 (d, *J* = 5.9 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 172.4, 132.9, 128.8, 108.3, 82.8, 76.5, 73.5, 72.4, 61.8, 27.1, 26.7, 16.2, 13.9; HRMS (CI)

calcd for $[C_{13}H_{22}O_4 + Na]^+$: 297.1309, Found: 297.1294. **15b** R_f = 0.14 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3298, 2983, 1723; $[\alpha]^{25}_D$ +9.8 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 7.01 (dd, *J* = 15.6, 4.2 Hz, 1H), 6.18 (dd, *J* = 15.6, 2.0 Hz, 1H), 4.56 (ddd, *J* = 7.9, 4.2, 2.2 Hz, 1H), 4.21 (q, *J* = 7.2 Hz, 2H), 4.09 (ddd, *J* = 13.1, 6.2, 6.0 Hz 1H), 3.70-3.62 (m, 2H), 2.77 (d, *J* = 5.9 Hz, 1H), 2.39 (d, *J* = 6.7 Hz, 1H), 1.42 (s, 3H), 1.39 (s, 3H), 1.38 (d, *J* = 5.9 Hz, 3H), 1.30 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.4, 147.0, 122.2, 108.7, 81.7, 75.9, 74.0, 70.7, 60.6, 27.3, 26.9, 19.1, 14.2; HRMS (CI) calcd for $[C_{13}H_{22}O_4 + Na]^+$: 297.1309, Found: 297.1313.

(*E*)-ethyl 3-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolane-4'-yl)acrylate (13).

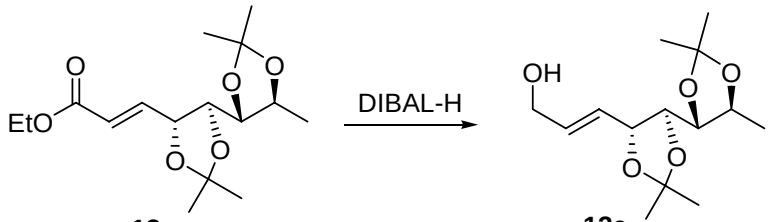


15b **13**

To a solution of diol **15b** (405 mg, 1.48 mL) in 25 mL acetone was added 2,2-dimethoxypropane (1.9 mL, 14.8 mmol) and *p*-toluenesulfonic acid monohydrate (29 mg, 0.15 mmol) at 0 ^oC. In two hour, the reaction was quenched by adding sat'd $NaHCO_3$. Then 15 mL Et_2O and 10 mL H_2O was added. The aqueous layer was extracted with Et_2O. The combined organic layers were wished with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided acetonide **13** (440 mg, 95%) as a colorless oil. R_f = 0.57 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1714; $[\alpha]^{25}_D$ +14.0 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 6.99 (dd, *J* = 15.6, 4.3 Hz, 1H), 6.14 (dd, *J* = 15.8, 1.8 Hz, 1H), 4.56 (ddd, *J* = 7.5, 4.3, 1.8 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 4.01 (dd, *J* = 7.5, 6.2 Hz, 1H), 3.68 (dd, *J* = 7.9, 7.5 Hz, 1H), 3.54 (dd, *J* = 7.7, 7.7 Hz, 1H), 1.40 (s, 3H), 1.39 (s, 6H), 1.34 (d, *J* = 5.9 Hz, 3H), 1.33 (s, 3H), 1.27 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 166.3, 145.0, 121.4, 110.4, 109.1, 83.1, 81.5, 79.3, 76.6, 60.5, 27.4, 27.0, 26.9, 26.8, 18.5, 14.3; HRMS (CI) calcd for $[C_{16}H_{26}O_4 + Na]^+$: 337.1622, Found:

337.1618.

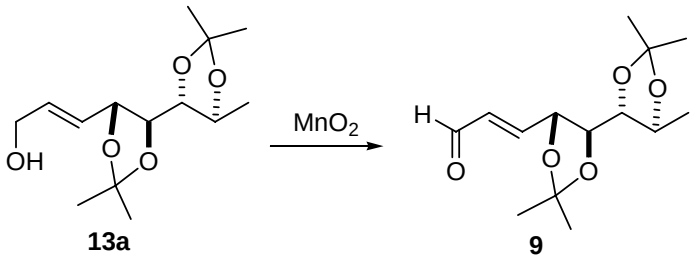
(*E*)-3-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolane-4'-yl)prop-2-en-1-ol (13a).



13 **13a**

To a solution of ester **13** (413 mg, 1.32 mmol) in 7 mL of THF was added DIBAL-H (4.9 ml, 1.0 M in hexanes, 4.0 mmol) dropwise at –78 °C. In 30 min, the reaction was quenched by adding 3 mL of acetone and 10 mL of 10% NaOH solution. The mixture was filtered through a pad of celite. The aqueous layer was extracted with Et_2O. The combined organic layers were wished with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided allylic alcohol **13a** (317 mg, 89% yield) as a colorless oil. R_f = 0.14 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3427, 2982; $[\alpha]^{25}_D$ +8.8 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 5.99 (dd, *J* = 15.5, 4.9, 0.8 Hz, 1H), 5.76 (ddd, *J* = 15.4, 6.1, 1.6, 1.4 Hz, 1H), 4.44 (dd, *J* = 7.1, 6.5 Hz, 1H), 4.15-4.14 (m, 2H), 4.02 (dq, *J* = 7.7, 5.9 Hz, 1H), 3.69 (dd, *J* = 7.1, 7.1 Hz, 1H), 3.57 (dd, *J* = 7.7, 6.9 Hz, 1H), 2.05 (bs, 1H), 1.39 (s, 3H), 1.38 (s, 6H), 1.33 (s, 3H), 1.32 (d, *J* = 5.9 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 132.6, 128.3, 109.4, 108.8, 82.6, 81.3, 79.5, 75.6, 62.6, 27.3, 26.9, 26.9, 26.8, 18.6; HRMS (CI) calcd for $[C_{14}H_{24}O_5 + Na]^+$: 295.1516, Found: 295.1514.

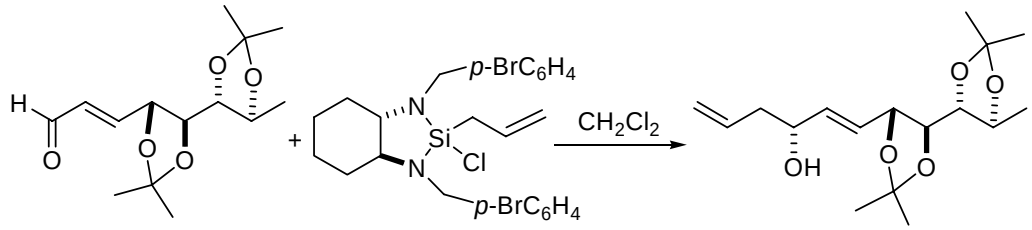
(*E*)-3-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolane-4'-yl)acrylaldehyde (9).



13a **9**

To a solution of alcohol **13a** (240 mg, 0.88 mmol) in 9 mL of CH_2Cl_2 was added MnO_2 (767 mg, 8.8 mmol) at room temperture. In 12 h, the reaction mixture was filtered through a pad of celite and washed with EtOAc. The organic layers were wished with brine and dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (8:2 (v/v) hexane/EtOAc) provided aldehyde **9** (234 mg, 92% yield) as a white solid. R_f = 0.53 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1682; $[\alpha]^{25}_D$ +36.1 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 9.59 (d, *J* = 7.9, Hz, 1H), δ 6.88 (dd, *J* = 15.8, 4.0 Hz, 1H), 6.45 (ddd, *J* = 15.8, 7.9, 1.6 Hz, 1H), 4.66 (ddd, *J* = 7.7, 3.8, 1.6, Hz, 1H), 4.02 (dq, *J* = 7.5, 5.9 Hz, 1H), 3.68 (dd, *J* = 8.1, 7.9 Hz, 1H), 3.55 (dd, *J* = 8.1, 7.7 Hz, 1H), 1.42 (s, 3H), 1.41 (s, 3H), 1.40 (s, 3H), 1.36 (d, *J* = 6.1 Hz, 3H), 1.33 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 193.3, 153.5, 131.3, 110.7, 109.1, 83.0, 81.5, 79.5, 76.8, 27.3, 26.8, 26.8, 26.5, 18.3; HRMS (CI) calcd for $[C_{14}H_{22}O_5 + Na]^+$: 293.1359, Found: 293.1366.

(3*R*,*E*)-1-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)hexa-1,5-dien-3-ol (17a).

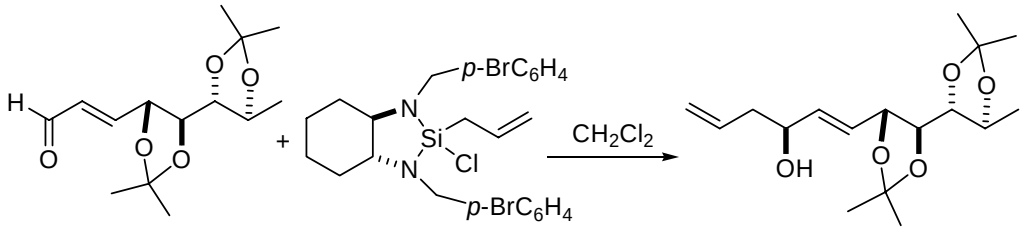


9 (*S*,*S*)-**16** **17a**

To a solution of **(*S*,*S*)-16** (690 mg, 1.25 mmol) in 4.25 mL of CH_2Cl_2 was added aldehyde **9** (135 mg, 0.5 mmol) in 2 mL of CH_2Cl_2 dropwise at −10 °C. The reaction flask was put in a freezer (−10 °C). In 36 h, the reaction was quenched by adding 1 N HCl and EtOAc, and the mixture was vigorously stirred at room temperature for 15 min. The mixture was

filtered through a pad of celite and the layers were separated. The aqueous layer was extracted with EtOAc. The combined organic layers were wished with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **17a** (143 mg, 92% yield) as a white solid. R_f = 0.23 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 3453, 2989, 1637; $[\alpha]^{25}_D$ +13.8 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 5.90 (ddd, *J* = 15.6, 5.4, 1.2 Hz, 1H), δ 5.80 (dddd, *J* = 16.8, 10.8, 7.2, 7.2 Hz, 1H), 5.77 (ddd, 15.6, 6.6, 1.2 Hz, 1H), 5.15-5.11 (m, 2H), 4.44 (dd, *J* = 7.2, 6.6 Hz, 1H), 4.23 (dq, *J* = 5.4, 1.2 Hz, 1H), 4.03 (ddd, *J* = 10.2, 7.8, 5.4 Hz, 1H), 3.68 (dd, *J* = 7.2, 7.2 Hz, 1H), 3.58 (dd, *J* = 7.8, 7.2 Hz, 1H), 2.34 (ddddd, *J* = 12.6, 7.2, 5.4, 1.2, 1.2 Hz, 1H), 2.28 (ddddd, *J* = 13.8, 7.2, 7.2, 1.2, 1.2 Hz, 1H), 1.40 (s, 3H), 1.39 (s, 3H), 1.39 (s, 3H), 1.33 (s, 3H), 1.33 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 135.4, 133.9, 127.9, 118.3, 109.4, 108.7, 82.6, 81.4, 79.7, 75.7, 70.5, 41.5, 27.3, 26.9, 26.9, 26.8, 18.5; HRMS (CI) calcd for $[C_{17}H_{28}O_5 + Na]^+$: 335.1829, Found: 335.1846.

(3*S*,*E*)-1-((4'*R*,5'*S*)-2,2-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)hexa-1,5-dien-3-ol (17b).

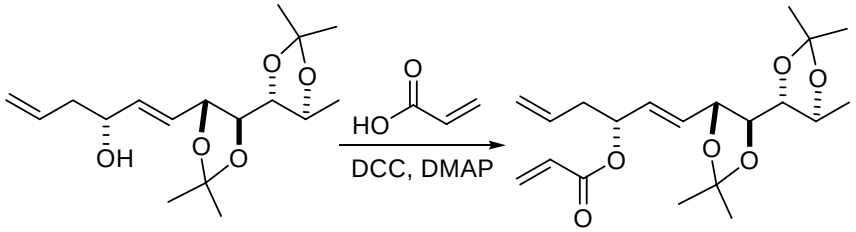


9 (*R*,*R*)-**16** **17b**

To a solution of **(*R*,*R*)-16** (690 mg, 1.25 mmol) in 4.25 mL of CH_2Cl_2 was added aldehyde **9** (135 mg, 0.5 mmol) in 2 mL of CH_2Cl_2 dropwise at –10 °C. The reaction flask was put in a freezer (–10 °C). In 38 h, the reaction was quenched by adding 1 N HCl and EtOAc, and the mixture was vigorously stirred at room temperature for 15 min. The mixture was filtered through a pad of celite and the layers were separated. The aqueous layer was extracted with EtOAc. The combined organic layers were wished with brine, dried over anhydrous Na_2SO_4, and concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided compound **17b** (148 mg,

95% yield) as a colorless oil. IR (neat, cm^{-1}) 3491, 2989, 1642; $[\alpha]^{25}_D$ +6.5 (*c* 2, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 5.86 (dd, 15.6, 6.0, 1H), 5.78 (dddd, *J* = 17.4, 10.2, 7.2, 7.2 Hz, 1H), 5.73 (dd, 15.0, 6.0 Hz 1H), 5.13-5.09 (m, 2H), 4.42 (dd, *J* = 7.2, 6.6 Hz, 1H), 4.18 (dd, *J* = 12.6, 6.0 Hz, 1H), 4.01 (dq, *J* = 7.8, 6.0 Hz, 1H), 3.67 (dd, *J* = 7.2, 7.2 Hz, 1H), 3.56 (dd, *J* = 7.8, 7.2 Hz, 1H), 2.34-2.26 (m, 2H), 1.39 (s, 3H), 1.38 (s, 3H), 1.38 (s, 3H), 1.32 (s, 3H), 1.32 (d, *J* = 6.0 Hz, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 135.5, 133.9, 128.4, 118.3, 109.5, 108.8, 82.6, 81.3, 79.7, 75.7, 71.0, 41.6, 27.3, 26.9, 26.9, 26.8, 18.5; HRMS (CI) calcd for $[C_{17}H_{28}O_5 + Na]^+$: 335.1829, Found: 335.1812.

(3*R*,*E*)-1-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)hexa-1,5-dien-3-yl acrylate (8).

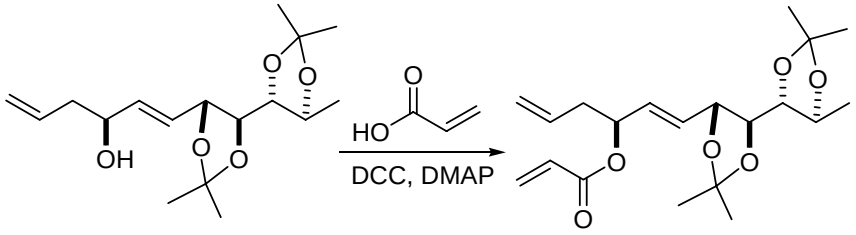


17a **8**

To a solution of alcohol **17a** (116 mg, 0.37 mmol) in 2 mL of CH_2Cl_2 was added acrylic acid (0.11 mL, 1.49 mmol), DCC (306 mg, 1.49 mmol) and DMAP (5 mg, catalytic amount). In 4 h, the reaction mixture was diluted with Et_2O and filtered through a pad of celite and washed with Et_2O. The organic layer was washed with sat'd aqueous $NaHSO_4$, sat'd aqueous $NaHCO_3$, brine and dried over anhydrous Na_2SO_4, concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided ester **8** (108 mg, 78% yield) as a colorless oil. R_f = 0.69 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2987, 1736; $[\alpha]^{25}_D$ +24.1 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 270 MHz) δ 6.39 (dd, *J* = 17.3, 1.5 Hz, 1H), 6.15 (dd, *J* = 17.3, 10.1 Hz, 1H), 5.84-5.67 (m, 4H), 5.45-5.39 (m, 1H), 5.13-5.04 (m, 2H), 4.44 (dd, *J* = 7.4, 2.5 Hz, 1H), 4.01 (ddd, *J* = 13.3, 6.2, 5.9 Hz, 1H), 3.64 (dd, *J* = 7.4, 7.2 Hz, 1H), 3.55 (dd, *J* = 7.4, 7.4 Hz, 1H), 2.46-2.41 (m, 2H), 1.40 (s, 6H), 1.38 (s, 3H), 1.33 (d, *J* = 6.0 Hz, 3H), 1.30 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 165.1, 132.9, 130.8, 130.7, 129.9, 128.6, 118.1, 109.6, 108.8, 82.7, 81.6, 79.5, 76.0, 72.9, 38.8, 27.3, 26.9 (2C), 26.7, 18.4; HRMS (CI) calcd for $[C_{20}H_{30}O_6 + Na]^+$:

389.1935, Found: 389.1928.

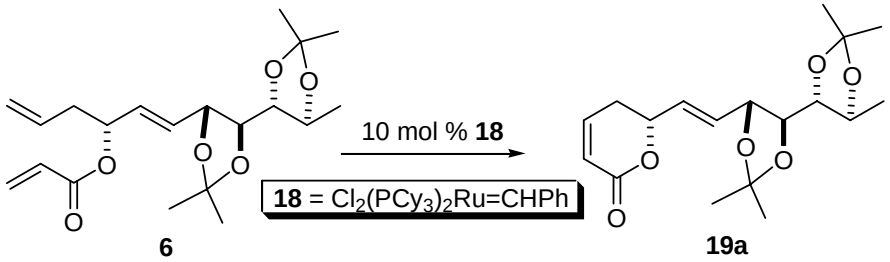
(3*S*,*E*)-1-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)hexa-1,5-dien-3-yl acrylate (8b).



17b **8b**

To a solution of alcohol **17b** (120 mg, 0.39 mmol) in 5 mL of CH_2Cl_2 was added acrylic acid (0.12 mL, 1.55 mmol), DCC (320 mg, 1.55 mmol) and DMAP (5 mg, catalytic amount). In 3 h, the reaction mixture was diluted with Et_2O and filtered through a pad of celite and washed with Et_2O. The organic layer was washed with sat'd aqueous $NaHSO_4$, sat'd aqueous $NaHCO_3$, brine and dried over anhydrous Na_2SO_4, concentrated to afford the crude product. Flash chromatography on silica gel (9:1 (v/v) hexane/EtOAc) provided ester **8b** (106 mg, 76% yield) as a colorless oil. R_f = 0.68 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2988, 1739; $[\alpha]^{25}_D$ –18.5 (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 270 MHz) δ 6.37 (dd, *J* = 17.3, 1.5 Hz, 1H), 6.08 (dd, *J* = 17.3, 10.4 Hz, 1H), 5.85-5.62 (m, 3H), 5.37 (dt, *J* = 11.6, 6.2 Hz, 1H), 5.10-5.03 (m, 2H), 4.40 (dd, *J* = 6.4, 6.2 Hz, 2H), 4.06-3.96 (m, 1H), 3.63 (dd, *J* = 7.4, 7.2 Hz, 1H), 3.54 (d, *J* = 7.4, 7.4 Hz, 1H), 2.69-2.64 (m, 1H), 2.40-2.33 (m, 1H), 1.38 (s, 9H), 1.32 (d, *J* = 5.7 Hz, 3H), 1.31 (s, 3H); ^{13}C NMR ($CDCl_3$, 67.5 MHz) δ 165.2, 132.9, 130.7, 130.6, 130.5, 128.6, 118.1, 109.6, 108.8, 82.7, 81.4, 79.6, 75.9, 72.9, 38.8, 27.3, 26.8 (2C), 26.7, 18.5; HRMS (CI) calcd for $[C_{20}H_{30}O_6 + Na]^+$: 389.1935, Found: 389.1941.

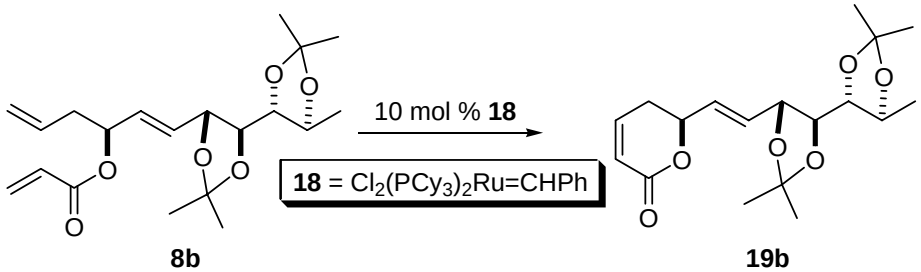
(6*R*)-5,6-dihydro-6-((*E*)-2'-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)pyran-2-one (19a).



6 **19a**

To a solution of triene **6** (80 mg, 0.22 mmol) in 11 mL of CH_2Cl_2 was added Grubbs catalyst (18 mg, 10 %mmol) in 11 mL CH_2Cl_2. The reaction was heated at reflux for 2 h. Solvent was removed under reduced pressure and the residue was purifird by flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided lactone **19a** (61 mg, 82% yield) as a colorless oil. R_f = 0.14 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2983, 1742; $[\alpha]^{25}_D$ +65.4 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.88 (ddd, *J* = 9.6, 5.4, 3.0 Hz, 1H), 6.04 (ddd, *J* = 9.6, 2.4, 1.2 Hz, 1H), 5.98-5.92 (m, 2H), 4.97(ddd, *J* = 10.8, 4.2, 4.2 Hz, 1H), 4.47 (dd, *J* = 7.8, 4.2 Hz, 1H), 4.02 (dq, *J* = 7.8, 6.0 Hz, 1H), 3.68 (dd, *J* = 7.8, 7.2 Hz, 1H), 3.56 (dd, *J* = 7.8, 7.8 Hz, 1H), 2.50 (dddd, *J* = 18.0, 4.86, 1.2, 0.6 Hz,, 1H), 2.41 (dddd, *J* = 10.8, 7.8, 3.0, 2.4 Hz,, 1H), 1.40 (s, 6H), 1.40 (s, 3H), 1.34 (s, 3H), 1.34 (d, *J* = 6.0 Hz, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 163.6, 144.3, 131.3, 128.9, 121.6, 109.8, 108.9, 82.8, 81.5, 79.4, 76.8, 76.1, 29.5, 27.3, 26.9 (2C), 26.8, 18.5; HRMS (CI) calcd for $[C_{18}H_{26}O_6 + Na]^+$: 361,1622, Found: 361.1605.

(6*S*)-5,6-dihydro-6-((*E*)-2'-((4'*R*,5'*S*)-2',2'-dimethyl-5'-((4"*R*,5"*S*)-2",2",5"-trimethyl-1",3"-dioxolan-4"-yl)-1',3'-dioxolan-4'-yl)pyran-2-one (19b).

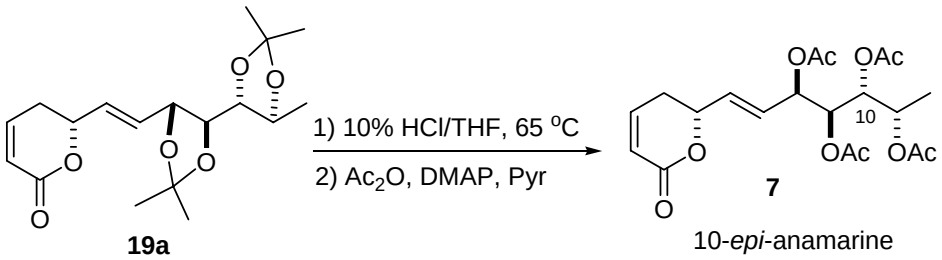


8b **19b**

To a solution of triene **8b** (57 mg, 0.15 mmol) in 7.5 mL of CH_2Cl_2 was added Grubbs catalyst (14 mg, 10 %mmol) in 7.5 mL CH_2Cl_2. The reaction was heated at reflux for 3 h. Solvent was removed under reduced pressure and the residue was purifird by flash chromatography on silica gel (7:3 (v/v) hexane/EtOAc) provided lactone **19b** (40 mg,

80% yield) as a colorless oil. R_f = 0.14 (7:3 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2983, 1742; $[\alpha]^{25}_D$ –4.9 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.88 (ddd, *J* = 9.6, 5.4, 3.0 Hz, 1H), 6.03 (ddd, *J* = 10.2, 1.8, 1.8 Hz, 1H), 5.98-5.92 (m, 2H), 4.97(ddd, *J* = 9.6, 5.4, 4.8 Hz, 1H), 4.47 (dd, *J* = 7.8, 4.2 Hz, 1H), 4.02 (dq, *J* = 7.8, 6.0 Hz, 1H), 3.66 (dd, *J* = 7.8, 7.2 Hz, 1H), 3.53 (dd, *J* = 7.8, 7.2 Hz, 1H), 2.44-2.42 (m, 2H), 1.39 (s, 6H), 1.38 (s, 3H), 1.33 (d, *J* = 6.0 Hz, 3H), 1.38 (s, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz) δ 163.7, 144.5, 131.5, 128.2, 121.6, 109.8, 108.9, 82.9, 81.6, 79.4, 77.1, 76.3, 29.6, 27.3, 26.9, 26.8 (2C), 18.5; HRMS (CI) calcd for $[C_{18}H_{26}O_6 + Na]^+$: 361.1622, Found: 361.1605.

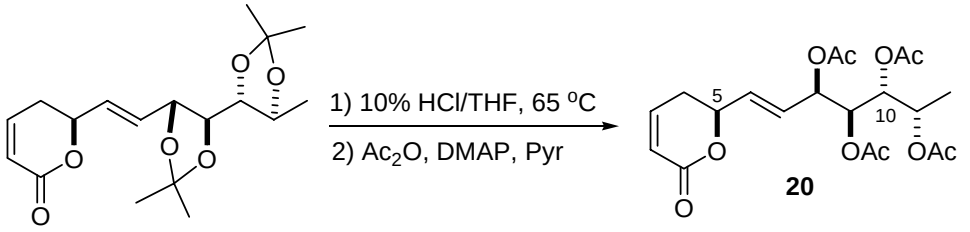
10-*epi*-anamarine (7).



A solution of 10% aqueous HCl and THF (1 : 1, 1.4 ml) was added to a flask containing acetonide 1**9a** (27 mg, 0.08 mmol). The mixture was hearted at 65 °C for 20 min and the solvent was removed at reduced pressure. The residue was dissolved in 1.0 ml of pyridine, and then Ac_2O (76 μl, 1.6 mmol) and cat. amout DMAP were added. In 24 h, solid $NaHCO_3$ was added, diluted with EtOAc, and then filtered through a pad of celite. The solvent was removed under reduced pressure and the residue was purified by flash chromatography on silica gel (50:50 (v/v) hexane/EtOAc) provided 10-*epi*-anamarine **7** (30 mg, 86% yield) as a white solid. R_f = 0.15 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2925, 1745; $[\alpha]^{25}_D$ +29.8 (*c* 0.5, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.85 (ddd, *J* = 9.6, 6.0, 3.0 Hz, 1H), 6.03 (ddd, *J* = 9.6, 1.2, 1.2 Hz, 1H), 5.81 (ddd, *J* = 15.6, 5.4, 1.8 Hz, 1H), 5.68 (ddd, *J* = 15.6, 5.4, 1.2 Hz, 1H), 5.51 (dd, *J* = 5.4, 1.2 Hz, 1H), 5.28 (dd, *J* = 10.2, 2.4 Hz, 1H), 5.22 (dd, *J* = 10.2, 1.8 Hz, 1H), 5.10 (dq, *J* = 2.4, 6.6 Hz, 1H), 4.93 (dq, *J* = 4.8, 4.8 Hz, 1H), 2.41 (dddd, *J* = 18.0, 6.0, 4.2, 1.2 Hz, 1H), 2.34 (dddd, *J* = 18.0, 10.8, 3.0, 2.4 Hz, 1H), 2.13 (s, 3H), 2.11 (s, 3H), 2.05 (s, 3H), 2.04 (s, 3H), 1.13 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz): δ 170.3, 170.0, 169.9, 169.8, 163.2, 144.2,

130.2, 127.4, 121.6, 76.3, 70.5, 69.9, 69.5, 67.1, 29.7, 21.0, 20.8, 20.6, 20.6, 16.2; HRMS (CI) calcd for $[C_{20}H_{26}O_{10} + Na]^+$: 449.1419, Found: 449.1403.

5,10-*epi,epi*-anamarine (20).



19b **20**

5,10-*epi,epi*-anamarine

A solution of 10% aqueous HCl and THF (1 : 1, 1.4 ml) was added to a flask containing acetonide **9** (44 mg, 0.13 mmol). The mixture was hearted at 65 °C for 20 min and the solvent was removed at reduced pressure. The residue was dissolved in 1.0 ml of pyridine, and then Ac_2O (124 μl, 2.6 mmol) and cat. amout DMAP were added. In 24 h, solid $NaHCO_3$ was added, diluted with EtOAc and filtered through a pad of celite. The solvent was removed under reduced pressure and the residue was purified by flash chromatography on silica gel (50:50 (v/v) hexane/EtOAc) provided 5,10-*epi,epi*-anamarine **20** (47 mg, 80% yield) as a white solid. R_f = 0.15 (1:1 (v/v) hexane/EtOAc); IR (neat, cm^{-1}) 2989, 1682; $[\alpha]^{25}_D$ –41.2 (*c* 1, $CHCl_3$); ^1H NMR ($CDCl_3$, 600 MHz) δ 6.83 (ddd, *J* = 9.0, 5.4, 3.0 Hz, 1H), 6.02 (ddd, *J* = 10.2, 1.2, 1.2 Hz, 1H), 5.77 (ddd, *J* = 15.6, 6.0, 1.2 Hz, 1H), 5.68 (ddd, *J* = 15.6, 4.8, 1.2 Hz, 1H), 5.49 (dd, *J* = 3.6, 1.2 Hz, 1H), 5.30 (dd, *J* = 10.2, 2.4 Hz, 1H), 5.21 (dd, *J* = 10.2, 2.4 Hz, 1H), 5.09 (qd, *J* = 6.6, 1.8 Hz, 1H), 4.87(dq, *J* = 4.8, 4.8 Hz, 1H), 2.41 (dddd, *J* = 18.6, 5.4, 4.8, 1.2 Hz, 1H), 2.35 (dddd, *J* = 18.6, 10.2, 3.0, 2.4 Hz, 1H), 2.12 (s, 3H), 2.10 (s, 3H), 2.06 (s, 3H), 2.03 (s, 3H), 1.13 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 170.3, 169.9, 169.9, 169.7, 163.3, 144.1, 130.0, 127.8, 121.6, 70.5, 69.9, 69.4, 67.0, 67.0, 29.6, 29.4, 20.9, 20.8, 20.6, 16.1; HRMS (CI) calcd for $[C_{20}H_{26}O_{10} + Na]^+$: 449.1419, Found: 449.1423.